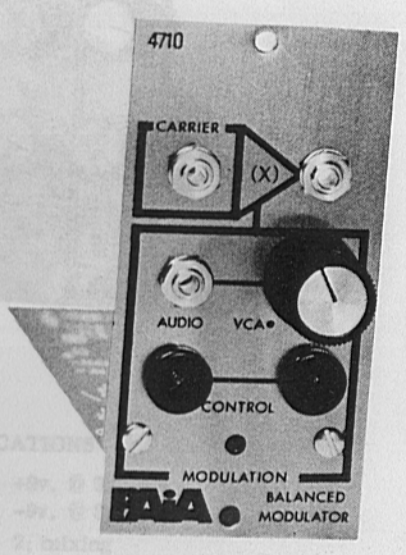
A simple means of getting around this is to have the keyboard generate octavely related voltages in the first place. This eliminates the need for a separate exponential converter on each oscillator and filter. And when you're talking about 3 or 4 VCOs and a couple of filters, this is a big savings in cost and drift problems.

4710 BALANCED MODULATOR



Conventional synthesizer components provide the user a multitude a sources of sound waveforms that are rich in harmonicly related frequencies, but only the Balanced Modulator provides the basis for generating sounds with component frequencies spaced according to non-harmonic intervals. While natural sounds with these properties are less than numerous (chimes, gongs, certain man-made whistles, insects and others), the sound of the suppressed carrier waveform can be one of the most distinctively "electronic".

The inputs and controls of the PAIA 4710 Balanced Modulator have been arranged to provide for this module's convenient use as a Voltage Controlled Amplifier as well as a sine wave frequency doubler.

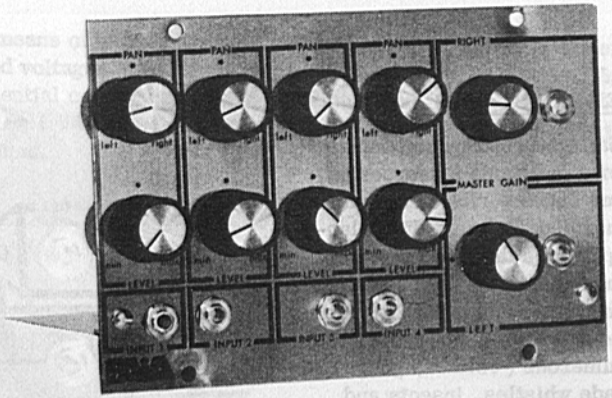
SPECIFICATIONS

Power Requirements:	+18v. @ 10 ma. +9v. @ 1.5 ma. -9v. @ 7 ma.
Input Impedance:	Carrier - 5K nominal Modulation - 50K nominal Control - 680K
Output Impedance:	3K nominal
Frequency Response:	15 Hz. to 30 kHz.
Carrier/Mod. Rejection:	50 db. typical

4711 MIXER

If there is one module that the developing synthesist never seems to have enough of it is mixers. Increasing expertise at the instrument produces increasing sophistication and subtlety in the sounds produced. In most cases the more subtle and "natural" the sound the more individual component sounds are required to produce it.

The PAIA 4711 Mixer allows for the mixing of up to 4 channels of program material with individual level controls for each channel. Pan pots allow the 4 input channels to be split between the two output channels in any proportion from 0 to 100%. Master gain controls on the output channels allow for raising and lowering the total output levels while maintaining constant percentage of program material from the 4 inputs.

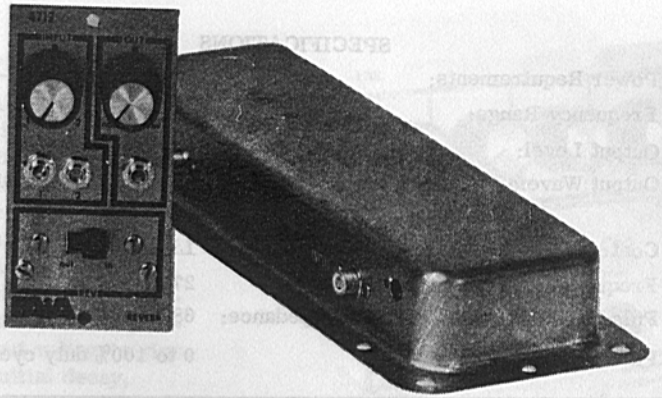


SPECIFICATIONS

Power Requirements:	+9v. @ 4 ma. -9v. @ 4 ma.
Input Impedance:	10K ohms
Output Impedance:	less than 100 ohms
Freq. Response: (3 db, 10K load)	5 Hz. to 20 kHz.
Max. Gain:	6 db.
Max. Input Level:	10v. p-p
Cross Talk:	-60 db.

4712 REVERB MODULE

A reverberation module is a natural addition to any synthesizer system since it provides an electro-mechanical equivalent to the delays and echos that define the acoustics of a large auditorium. The 4712 Reverb Module optimizes control flexibility by allowing for the mixing of two separate input signals as well as post-mixing of the input signals with the processed reverb signal. Front panel switch allows for instantaneous, pop-free termination of effects without affecting normal signal flow through the module.

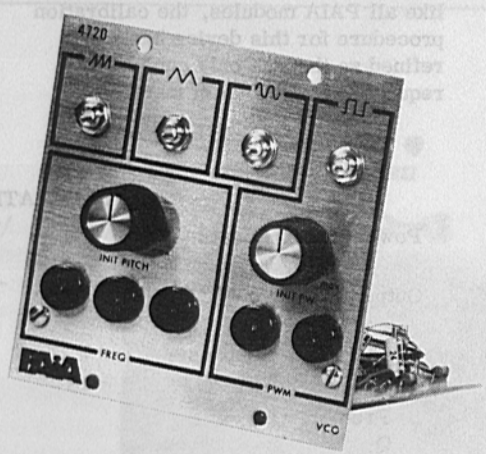


SPECIFICATIONS

Power Requirements:	+9v. @ 3.5 ma. -9v. @ 3.5 ma.
Inputs:	2; mixing
Input Impedance:	100K min.
Output Impedance:	less than 1K
Reverberation Time:	3 sec. nom.

4720 VOLTAGE CONTROLLED OSCILLATOR

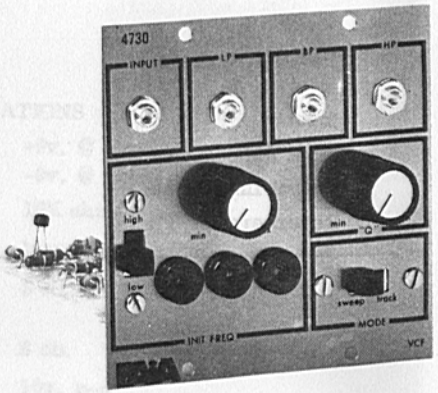
The 4720 Voltage Controlled Oscillator features simultaneous ramp, triangle, sine and pulse/square wave outputs; manually set or voltage controlled pulse width and 16 Hz. to 16 kHz. frequency response corresponding to 5 volt peak control voltage. Front panel initial pitch control allows multiple oscillators to be offset and track one another chromaticly over the entire operating range. A self-zeroing front end and active, on-board voltage regulation combine to make the 4720 extremely linear and stable.



SPECIFICATIONS

Power Requirements:	9 volts @ 20 ma.
Frequency Range:	16 Hz. to 16 kHz.
Output Level:	.5v. peak to peak
Output Waveforms:	ramp, triangle, sine, square/variable pulse
Control Voltage/Frequency Response:	Linear
Frequency Control Input Impedance:	270K
Pulse Width Modulation Input Impedance:	68K
Pulse Width Range:	0 to 100% duty cycle

4730 MULTI-MODAL FILTER



A good filter is the cornerstone of a music synthesis system. The PAIA 4730 has features that are ordinarily reserved for devices costing 5 to 20 times more. Including simultaneous low, high, and band-pass outputs and extreme linearity allowing the filter to track the keyboard for numerous interesting effects. Yet, like all PAIA modules, the calibration procedure for this device has been refined so that the only equipment required is a Volt-Ohm meter.

SPECIFICATIONS

Power Requirements:	+9v. @ 15 ma. -9v. @ 25 ma.
Outputs:	Low Pass, Band-Pass, High Pass Simultaneously available.
C. V./Freq. Response:	Linear
Ranges:	
Freq.:	16Hz. to 16 kHz.
Q:	.5 to 150
Input Impedance:	200K minimum
Control Input Impedance:	270K

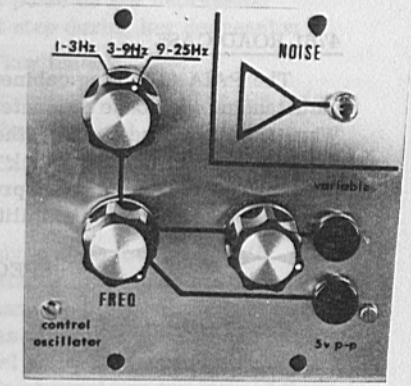
4740 ENVELOPE GENERATOR

The 4740 ADSR Envelope Generator provides the synthesist with a triggerable source of programmable time varying voltage that is useful in controlling filters, oscillators, amplifiers or other voltage controllable elements. Front panel controls allow independent, non-interactive adjustment of the output voltage's rise time (attack), initial decay, sustain level and final release time. Electrical and manual triggers are provided for and front panel light emitting diodes indicate status of module.

SPECIFICATIONS

Power requirements:	+18v. @ 17 ma.
Trigger input impedance:	66, 000 ohms nominal
Output impedance:	less than 1K ohms
Peak Output Voltage:	5 volts nominal
Attack, Decay, Release Time Range:	2 ms. to 1.5 sec. nom.
Triggering voltage:	3.5 volts nom.
Sustain Level Range:	.5 to 5 volts
Front Panel Indicators	attack and decay/ sustain Light Emitting Diodes

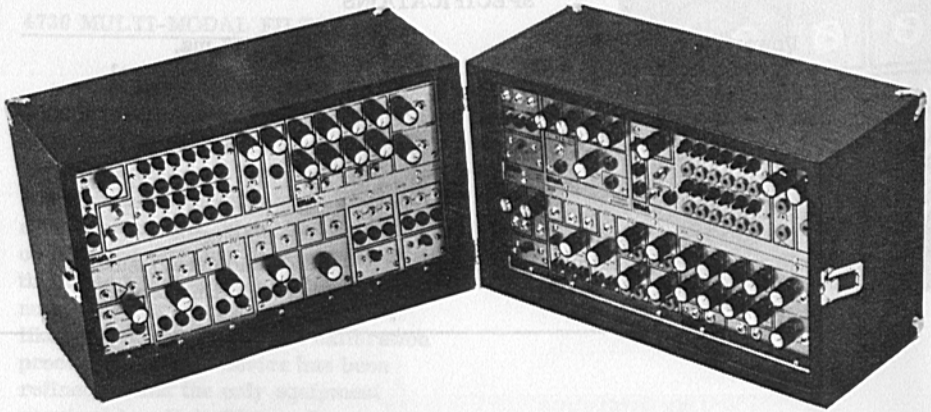
2720-5 CONTROL OSCILLATOR/ NOISE SOURCE



The 2720-5 Control Oscillator/ Noise Source is a dual function module providing a source of slowly varying sinusoidal control voltage for tremolo, vibrato, filter sweeping, etc. and a white noise source useful in a variety of special effects including wind and surf sounds.

SPECIFICATIONS

Module Power Requirements:	18v. @ 1.75 ma.
Oscillator:	
Output:	Sinusoidal
Output Impedance:	Nominal 5K or less
Output Amplitude:	One fixed 5v. p-p output One variable 0 to 5v. p-p
Output D.C. Bias:	50% of peak to peak value
Frequency Range:	1 to 25 Hz. in three overlapping ranges
Noise Source:	
Output:	Broadband noise nominal 100 Hz. to 10 kHz.
Output Impedance:	Nominal 1K
Output Amplitude:	.5v. p-p
Output D.C. Bias	None



4761 ROAD CASE

The PAIA 4761 wing cabinet is a rugged module case, capable of withstanding the abuse encountered when equipment is taken on the road. When used in a studio setup, the 4761 offers the versatility of rearranging the system in a "building block" fashion to suit the individual synthesist's needs. The 4761 front panel provides ground connections between cabinets and increased patching flexibility.

SPECIFICATIONS

Case Dimensions:	15-1/8" X 7" X 9-1/4"
Module Space:	13 single width modules

4782 KEYBOARD/CASE

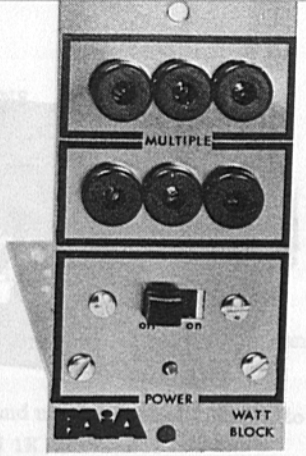
The 4782 is a self contained keyboard controller housed in a heavy duty roadworthy case. The three octaves of key selectable control voltage is suplemented by variable tuning, sample and hold, and variable glide circuitry. The self contained power supply eliminates the need for multiple power jumpers running to other cabinets. Glide circuitry allows sweeping tones such as trombone slides or steel guitar.

SPECIFICATIONS

Dimensions:	31" X 13" X 4"
Power Requirement:	110 volts AC
Internal Power Supply Output:	±9 volts @ 25 ma. +18 volts @ 5 ma.
Keyboard Style:	3 octaves of standard AGO configuration from C to C
Pitch control Range:	1 octave minimum
Slowest Glide Rate:	2.5 seconds across entire keyboard
Control voltage output:	.3 volts to 5 volts minimum
Trigger Voltage Output:	5 volt pulse on key depression 5 volt step during key depression
Tuning:	Each key tunable
Hold Time:	20 seconds minimum after key release
Output Impedance:	100 ohms nominal

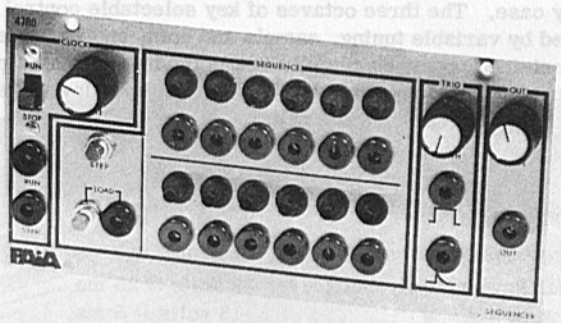
4770 WATT BLOCK

The 4770 is the basis of the power supply system for the 4700/S. Three of these modules provide the necessary DC voltages for proper operation of the modules. As the synthesizer system is expanded, the power supply modules are easily relocated, expanded or rewired as needed to suit the new system. A power switch is provided on the front panel as well as an LED indicator lamp to signify operation. Also mounted on the front panel are two sets of three jack multiples - one for control voltages, one for audio signals.



SPECIFICATIONS

Power Requirements:	117 v. 50/60 Hz.
Power output:	+9v. @ 100 ma.
	-9v. @ 100 ma.
	or
	+18v. @ 100 ma.



4780 SEQUENCER

In basic terms, a sequencer is simply another control voltage and trigger source. Unlike other controllers, however; it allows the user to pre-program an extended sequence of control voltage variations that can be called up on command and allows the variations to be executed at speeds beyond human capabilities. In addition to their obvious applications in generating fast arpeggios and automatic bass lines, sequencers can also be used as programmable function generators, counters or clock sources.

Considerable time and effort has gone into making the 4780 as versatile as possible without losing the user in a hopeless tangle of operational details. Many of the internal housekeeping functions are automatic yet externally available inputs and controls permit by-passing automatic functions in favor of manual control.

SPECIFICATIONS

Power RequirementsL	+18v. @ 50 ma.
	±9v. @ 1 ma.
Clock Rate:	2/sec. to 32/sec.
Control voltage range:	0 - 5 v. nominal

Additional Features: Built in glide, Light Emitting Diode indicates clock rate, LED stage status indicators, Manual and electrically activated controls, 2 to 12 event re-circulating count capabilities.

THE 4700/S AS A SYSTEM

The 4700/S is an assortment of the previously discussed modules which has capabilities competitive with commercial systems selling for several times the price. In fact, there are very few, if any, synthesizers in the "under $2000" bracket that include a sequencer as a standard function. Also, many low cost filters provide only low pass output, or a choice of low pass or band pass. Rarely do you see three simultaneous filter outputs available. The module complement of the 4700/S is such that the sequencer can control a full synthesizer by itself, and you still have a full array of modules for use with the keyboard.

Another concept of much debate is the modular patchable system versus the pre-patched switch operated system. There is no argument that the normalized synthesizers fill a very useful role - specifically the musician who wants to make ultra-fast changes on stage while he is performing, or someone who wants to add some new sounds to their repertoire without the need to fully understand what they are doing. But for those of us who want to really learn about the nature of sound, the patchable system can't be beat. Being able to utilize any module in any configuration draws every drop of performance out of the circuitry. After mastering the operation of the modules, most any sound that you can imagine can be duplicated on a patchable system. Further, the modular concept implies an obsolescence proof system, for as your ideas grow you can expand your system with a few more modules rather than selling the old system and replacing it with a bigger better model. Most people find that after using a patch system, it doesn't take that much longer to insert a few cords than it does to flip several switches. Thus, more and more patchable systems are being seen on the road with musicians.

The following section contains several examples of patches for the 4700/S system. Starting with these sounds will help explain the uses and capabilities of the modules. After initially setting up the patch, experiment with altered settings on the controls and listen to the changes that occur. This type of experimentation is very helpful in becoming more familiar with the system and how it works.

The symbology used in the following diagrams to represent the various modules is fully explained in the PAIA manual "A Schematic Symbology For Synthesizer Patching Arrangements" which is provided with this manual. We have chosen to represent synthesizer patches in this manner because many people physically arrange their modular systems in different configurations. The symbology system is universal and can be adapted to any synthesizer.

Best of luck in your experiments with the 4700/S; welcome to a whole new world of sound.

EFFECTS USING WHITE NOISE AS A SIGNAL SOURCE

The randomness and wide frequency content of white noise makes an ideal basis for many sounds both musical and special effect. The most obvious is simulating the wind or the sound of the surf. The noise output of the 2720-5 Control Oscillator Noise Source is patched to the 4730 filter input. The band-pass output is the output of the patch. As a control source for the filter you can use a randomly tuned sequencer with a lot of glide, an envelope generator with long attack and release times, the keyboard with long glide time, or the control oscillator output. Each of these controllers gives a different effect, but the common drawback is that they aren't completely random like Mother Nature's wind and surf. To increase randomness, feed more than one of these controllers into the three control voltage inputs of the filter. The random sequencer pattern can be occurring continuously while the keyboard output is user controlled to make the wind sweep higher or lower depending on the location of the key pressed. Additionally, an envelope generator can be triggered by the keyboard to cause an instantaneous gust of wind settling back to the level determined by which key was pressed.

Increasing the Q of the filter causes a narrower band of frequencies to be passed through the filter. With Q at maximum and the keyboard as the only control source, you can generate a melodic wind and actually play melodies.

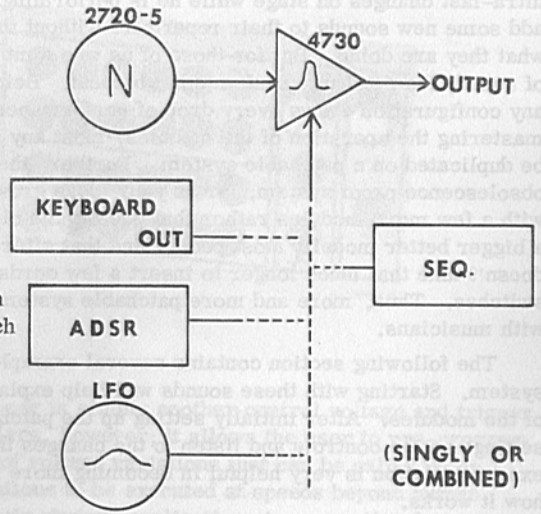


Figure 1 - WIND/SURF

Using an envelope generator to control a filter with low Q setting and range switch at LOW, some very effective thunder and explosion effects can be added. Also, try the low pass output for these type of effects. The envelope generators will most approximate an explosion with a minimum attack and long release.

Using the noise source through a VCA which is controlled by an envelope generator will produce hi-hat cymbal effects. Set the envelope attack at minimum and the release at about 20%. Patch the keyboard pulse trigger to the input of the envelope generator. Every time you hit a key the cymbal sound will be produced.

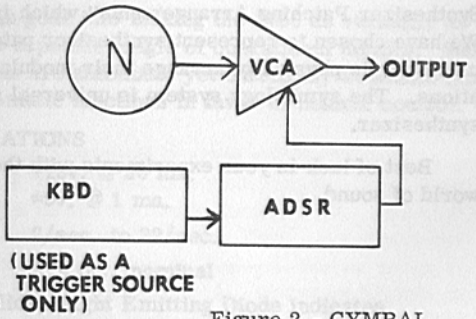


Figure 2 - CYMBAL

To add more expression to the sound keep your hand on the release control of the envelope generator and vary the setting for different beats. This gives the effect of the hi-hat cymbal opening and closing.

A keyboard controlled snare drum can be conceived which allows the user to play a melody on the drum. The keyboard control voltage output sets the pitch of the VCO to duplicate the "strike tone" normally provided by the tuned drum head. The triangle or sine VCO output is mixed with white noise at the mixer and processed through a VCA. The envelope generator for the VCA should have minimum attack and decay, maximum sustain and medium release. Triggering the envelope generator with the pulse keyboard trigger insures that the drum sound sill have no sustain. As an option, the noise source can be filtered prior to being mixed with the strike tone. Experiment with assorted combinations of filter output and control sources such as keyboard, envelope generator, or fixed bias (as outlined in the string patch section).

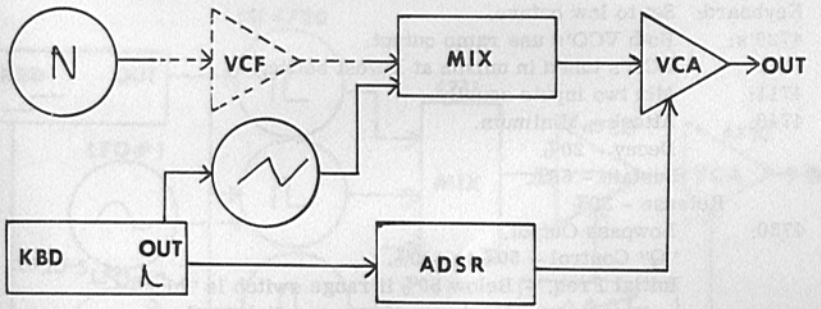


Figure 3 - MELODIC SNARE DRUM

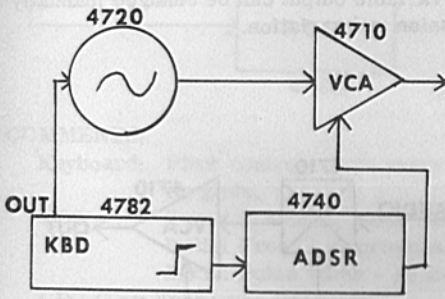


Figure 4 - FLUTE

COMMENTS:

4782: Pitch - Set to upper octave.
Glide - Off.

4720: Initial Freq. - Around 30 to 50%.

4740: Attack - 20%.
Decay - Minimum.
Sustain - Maximum.
Release - 20%.

This is a basic patch using the soft sine wave of a VCO to duplicate the sound of a flute. The medium attack and release on the envelope duplicates the effect of the build-up and collapse of the air column in the flute. The envelope generator, being triggered by the step trigger from the keyboard, will generate a sustained signal as long as a key is depressed. The balanced modulator is being used as a VCA for this patch.

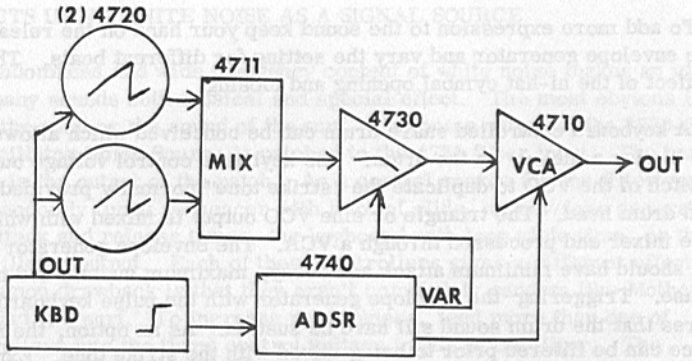


Figure 5 - FUNK BASS

COMMENTS:

Keyboard: Set to low octave.
4720's: Both VCO's use ramp output.
VCO's tuned in unison at lowest setting.
4711: Mix two inputs equally.
4740: Attack - Minimum.
Decay - 20%.
Sustain - 60%.
Release - 30%
4730: Lowpass Output.
"Q" Control - 50% to 100%.
Initial Freq. - Below 50% if range switch is "high".
Maximum if range switch is "low".

This patch gives the funky "wow" bass sound made popular by Stevie Wonder, the Bee Gees and many others. The 4740 variable output can be changed manually while you are playing for added expression and variation.

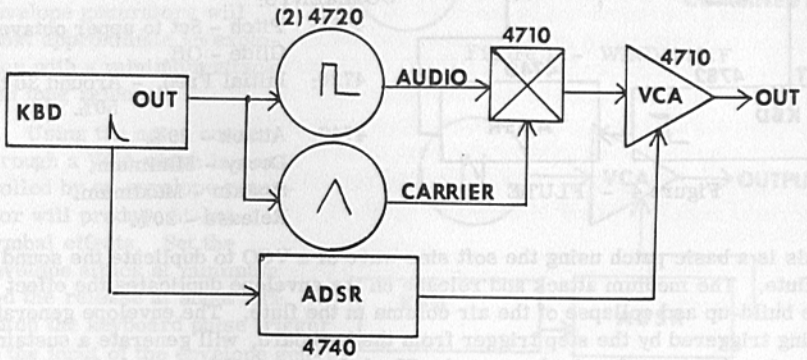


Figure 6 - CHIMES (AND OTHER METALLIC SOUNDS)

COMMENTS:

Keyboard: High octave, no glide.
4740: Attack - Minimum.
Decay - Minimum.
Sustain - Maximum.
Release - 50 to 100%.
4720's: Tune triangle VCO to an augmented fourth above the pulse VCO.
Pulse VCO pulse width - 30%.

This is a general purpose patch for bells. The settings shown will provide a sound of tubular chimes or church bells. Experiment with various permutations of this patch. How about a chime with sustain? To do this, use the keyboard step output rather than the pulse. Also play with the 4740 to get chimes with slow attack, etc. The biggest variables in this patch are the VCO's.

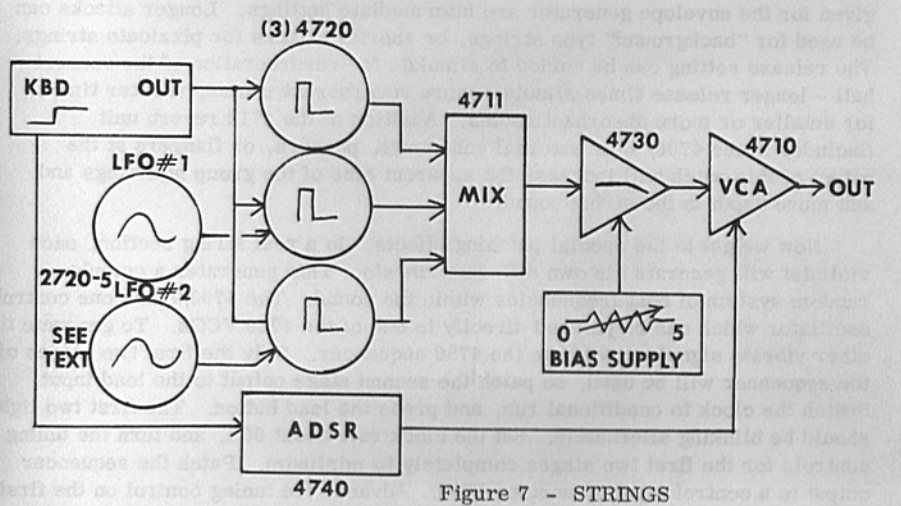


Figure 7 - STRINGS

COMMENTS:

Keyboard: Pitch control - high range.
No glide.
VCO's: Tuned in unison, pulse output.
Initial Freq. - Approximately 30%.
Initial Pulse Width - 10 to 20%.
LFO (Low Frequency Oscillator):
Approximately 10 Hz.
Very small output amplitude - 10%.
Mixer: All signals mixed equally.
Filter: Low pass output; Range- maximum; Q Control - 50%.
ADSR: Attack - 20%.
Decay - 30%.
Sustain - 60%.
Release - 50%.
Bias Supply (See Text) - Approximately 3 volts.

The sound of violins is a pleasing addition to any type of music. Strings are basicallly an easy sound to synthesize, but as you can see this patch uses some modules which aren't available in the 4700/S --- or are they? This patch was initially developed on a joint 4700/2720 PAIA system, but with some special patching, all functions can be obtained on the 4700/S. Hopefully, this will show the importance of experimenting with the modules to find applications which aren't immediately apparent from reading the front panel or instruction manuals. Performance above and beyond the call of duty, you might say.

The basic string sound comes from the narrow pulses generated by the VCO. Narrow pulses have a very widely distributed harmonic series and give a hollow, nasal effect. Three VCO's are used to get the effect of a whole string section playing at once. All oscillators are tracking in unison, and are mixed in equal proportions. The low pass filter takes the sharp edge off the sound to duplicate the natural harmonic roll-off of a violin around 8 kHz. The settings given for the envelope generator are intermediate settings. Longer attacks can be used for "background" type strings, or shorter attacks for pizzicato strings. The release setting can be varied to simulate the reverberation of the concert hall - longer release times simulate more reverberant rooms, shorter times for smaller or more absorbant rooms. Addition of the 4712 reverb unit (included in the 4700/S) or external echo units, phasers, or flangers at the output of this patch will increase the apparent size of the group of strings and add more depth to the string sound.

Now we get to the special patching effects. In a real string section, each violinist will generate his own different vibrato. This generates a complex random system of beat frequencies within the sound. The 4700/S has one control oscillator which can be patched directly to one of the 4720 VCOs. To generate the other vibrato signal we will use the 4780 sequencer. Only the first two stages of the sequencer will be used, so patch the second stage output to the load input. Switch the clock to conditional run, and press the load button. The first two lights should be blinking alternately. Set the clock rate about 60%, and turn the tuning controls for the first two stages completely to minimum. Patch the sequencer output to a control input on another VCO. Advance the tuning control on the first stage until you begin to hear an up/down trilling effect. Fine tune this setting to get the amount of vibrato depth you will want. Now, advance the glide control in the output section until the vibrato smooths out to an approximate sine wave. Fine tune the vibrato rate (clock rate), vibrato depth (stage one tuning) and glide rate. If you are more ambitious, more stages of the sequencer could be used to provide a pseudo-random vibrato signal.

The fixed bias supply can be achieved by patching the full level output of the unused envelope generator to its own trigger input. Set all controls to minimum except sustain at maximum, and press the manual trigger button. The 4740 should latch in the sustain mode, and the proper LED should remain lighted. The variable output now becomes a source of 0 to 5 volt regulated bias voltage. This voltage is patched to the control input of the 4730 filter and adjusted for the "stringiest" sound. Some may prefer to have the Q control higher than suggested, but as always - experiment will all controls to adjust the sound to your own taste.